Assessment of Color Stability in Single-Shade Composite Resin Compared to Multi-Shade Composite after Exposure to A Staining Agent.
(A Comparative in Vitro Study)

Sarah Mahmoud Hussein Afifi*

Abstract:
Objectives: to evaluate the color stability in single-shade composite in comparison to multi-shade composite. Methods: 30 discs (n=10) were prepared from 3 different composite materials, two materials (Venus diamond and Charisma Topaz, Heraeus Kulzer) and (3MTM FiltekTM Supreme) was fabricated using a Teflon mold. The specimens were immersed in a coffee solution, before immersing each resin-based composite in coffee (to-baseline) (t0), after 3 days (t1), after one weeks (t2), and after 2 weeks (t3) in the staining solution, readings were taken. The specimens’ colors were measured using a Reflective spectrophotometer. Results: At all evaluation times, it was found that composite Group 3 [charisma topaz] recorded highest color change mean value followed by composite Group 2 [Venus diamond] mean value while the lowest recorded color change mean value was for Group 1 [3M filtek supreme]. The difference between composite groups was statistically significant as demonstrated by one-way ANOVA test (p < 0.05). Pair-wise Tukey’s post-hoc showed non-significant (p>0.05) difference between Group 1 and Group 2 means values after three days and two weeks. For all composite groups, it was found that two weeks evaluation time recorded highest color change followed by one week evaluation while the lowest recorded color change was after three days evaluation time. Conclusion: There was a difference in color change between the different composite types. Color stability is material and time dependent.

Key words: composite resin, color stability, shade, staining agent.

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**Introduction:**

Dental composites are used to restore fractured teeth and stabilize orthodontic devices inside of the oral cavity. The quality of any composite dental restoration is fully based on its physiological, chemical, and mechanical properties\(^{(1)}\). Today's resin composites offer the capacity to replicate the natural beauty of teeth, allowing for a relatively conservative treatment strategy.\(^{(2,3,4,5)}\).

Even though dental composite is an excellent material, it has serious drawbacks, such as discoloration. As it is composed of polymer, it degrades rapidly when exposed to oral conditions, beverages, and food. This creates color incompatibility and compromises aesthetics, necessitating frequent cleaning and, in extreme cases, restorative replacement, which is time-consuming and costly.\(^{(6,7,8)}\).

Recent years have seen the introduction of "one shade" or "single shade" composite resins\(^{(9)}\), to define resin-based composites that are meant to approximate all shades aesthetically with a single nominal shade. Based on this broad color-matching approach, it is believed that these materials merge perfectly with the surrounding dentition, regardless of the tooth shade. The technology utilized to develop Venus Diamond and Charisma Topaz (Kulzer) is based on the notion of "adaptive light matching," in which the restoration shade is accomplished by absorbing wavelengths emitted by the surrounding tooth shade.\(^{(10)}\).

Long-term exposure to certain food dyes (coffee in particular) can have a considerable impact on the color stability of modern aesthetic restorative materials, despite the composition of the materials\(^{(11)}\). therefore, the staining susceptibility of newly created resin composite materials is investigated\(^{(2)}\).

To evaluate the color stability of dental composites, spectrophotometric shade assessment has been proven to be more efficient and trustworthy than human shade estimation.\(^{(12)}\).

**Aim of the study:**

The aim of this study was to evaluate the color stability in single-shade composite in comparison to multi-shade composite.

**Material and Methods:**

**Study design**

**In Vitro study**

**Materials and Methods:**

In this study, the following instruments and equipment was used\(^{(13)}\).

1. Two types of composites: single shade and multi-shade.
2. Staining solutions.
3. Teflon mold.
5. Light cure.
7. Two glass slides with 1 mm thickness.
8. Low speed handpiece Multi-fluted tungsten carbide finishing bur (VERDANT, Poland).

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**Footnotes:**

\(^{(1)}\) Reference 1.
\(^{(2)}\) Reference 2.
\(^{(3)}\) Reference 3.
\(^{(4)}\) Reference 4.
\(^{(5)}\) Reference 5.
\(^{(6)}\) Reference 6.
\(^{(7)}\) Reference 7.
\(^{(8)}\) Reference 8.
\(^{(9)}\) Reference 9.
\(^{(10)}\) Reference 10.
\(^{(11)}\) Reference 11.
\(^{(12)}\) Reference 12.
\(^{(13)}\) Reference 13.
Preparation and distribution of the samples:
30 discs (n=10) from the two materials (Venus diamond and Charisma Topaz, Heraeus Kulzer) and (3M FiltekTM Supreme) (table 1) was fabricated using a Teflon mold with the following dimensions: 20 mm in diameter, 2 mm in thickness, and a central hole measuring 6 mm in diameter. Using modeling equipment, the resin composites was inserted into the mold, and each side was covered with a Mylar strip. Before curing, two 1 mm-thick glass slides were inserted on both sides of the strips to flatten the surfaces. The samples were next be cured for 20 seconds (fig.1) on each surface using an LED Curing Light operating in standard mode with an irradiation of 1200 mW/cm^2. All samples were finished for fifteen seconds with a multi-fluted tungsten carbide finishing bur (VERDANT, Poland). The specimens were be completely cleaned with distilled water and air dried before further polishing procedures. The samples were next be polished with the Hiluster two-step polishing method (Kerr MFG, Orange, CA, USA). The Gloss PLUS aluminum oxide polisher was utilized for 30 seconds, followed by the HiLuster PLUS Dia diamond polisher. All specimens will be then immersed in an ultrasonic water bath for five minutes to eliminate any residual polishing debris. Storage was done Before processing; samples was kept in distilled water at room temperature for 24 hours.

Discoloration Procedure:
The coffee solution preparation, 3.6 g of the coffee (Nescafe Classic, Nestle, Switzerland) was dissolved in 300 mL of boiling distilled water. Before immersing each resin-based composite in coffee (to-baseline) (t_0), after 3 days (t_1), after one weeks (t_2), and after 2 weeks (t_3) in the staining solution, readings were taken.

Color change measurement:
The specimens’ colors were measured using a Reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). A white background was selected and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65, also hue and chroma were recorded. The color changes (ΔE) of the specimens were evaluated using the following formula: ΔE_{CIELAB} = (∆L^*^2 + ∆a^*^2 + ∆b^*^2) ^{1/2}

Where: L^* = lightness (0-100), a^* = (change the color of the axis red/green) and b^* = (color variation axis yellow/blue).(14)

![Fig.1 composite disc cured for 20 seconds](image)
Table (1):

<table>
<thead>
<tr>
<th>Materials</th>
<th>shade</th>
<th>filler</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charisma Topaz</td>
<td>A2 enamel</td>
<td>Nano-hybrid</td>
<td>Matrix: TCD-D1-HEA Filler: Barium aluminum fluoride glass filler of 0.02 – 2 μm, 5 vol% pyrogenic silicon dioxide filler of 0.02 – 0.07 μm. 76 wt%, 65 vol%</td>
<td>KulzerGmbh, Hanau (Germany)</td>
</tr>
<tr>
<td>Filtek Ultimate</td>
<td>A2 enamel</td>
<td>Nano-filled</td>
<td>Matrix: Bis-GMA, UDMA, TEGDMA, PEGDMA, Bis-EMA Filler: Silica filler (20 nm), zirconia filler (4–11 nm), zirconia/silica cluster filler. 0.6 – 10 microns particle size. 78.5 wt%, 63.5 vol%</td>
<td>3M, MN, USA</td>
</tr>
<tr>
<td>Venus Diamond</td>
<td>A2 enamel</td>
<td>Nano-hybrid</td>
<td>Matrix UDMA, TCD-D1-HEA, TEGDMA Filler: Ba–Al–B–F–Si glass, SiO₂ 81 wt%,64 vol%</td>
<td>KulzerGmbh, Hanau (Germany)</td>
</tr>
</tbody>
</table>

**Sample size**

Sample size calculation was done using the comparison of color stability between single shade and multiple shade composite resins after exposure to staining agent. As reported in previous publication (15), the mean ± SD of color stability (ΔE00) in Filtek group was approximately 17.9 ± 1.5, while in Venus diamond group it was approximately 12.1 ± 1.0. Accordingly, we calculated that the minimum proper sample size was 10 composite discs in each group to be able to detect a real difference of 2 units with 80% power at α = 0.05 level using Student’s test for independent samples. Sample size calculation was done using PS Power and Sample Size Calculations Software, version 3.1.2 for MS Windows (16).

**Statistical analysis:**

The results were analyzed using Graph Pad Instate (Graph Pad, Inc.) software for windows. A value of P ≤ 0.05 was considered statistically significant. Continuous variables were expressed as the mean and standard deviation. After homogeneity of variance and normal distribution of errors had been confirmed, one-way analysis of variance was performed followed by Tukey’s post-hoc test if showed significance between variables. Two-way ANOVA compared the effect of each factor (composite group and evaluation time). Sample size (n=30/group) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.
Results:

Results of color change (ΔE):

Results of color change (Mean±SD) for groups of composites as use of evaluation time are sum up in table (2) and figure (2). Respecting all evaluation times, it was found that composite charisma topaz group 3 recorded highest change of color mean value come after Venus Diamond Group 2 mean value while the lowest recorded change of color mean value was 3M filtek supreme group 1. The difference between groups of composites were statistically significant as demonstrated by one-way ANOVA test (p < 0.05). Pair-wise Tukey’s post-hoc showed insignificant (p>0.05) difference between Group 1 and Group 2 means values after three days and two weeks as seen in table (2) and showed in figure (2). To all groups of composites, it was established that two weeks’ time of evaluation recorded highest change of color mean value come after by one week time of evaluation mean value while the lowest recorded change of color mean value was after three days’ time of evaluation. The difference among different evaluation times was statistically significant as demonstrated by one-way ANOVA test (p < 0.05), as shown in table (2) and illustrated in figure (2).

Total effect of composite material group on color change mean value:

Regardless to evaluation time, totally it was found that the differences between composite material groups were statistically significant as revealed by two-way ANOVA test (p=<0.0001<0.05) where (GIII > GII > GI).

Effect of evaluation time on color change mean value:

Irrespective of composite material group, totally it was found that color change means value increased by time significantly as demonstrated by two-way ANOVA test (P=<0.0001<0.05) i.e. where (two weeks > one week > three days).
Table (2): Color change (ΔE) results (Mean±SD) for composite groups as function of evaluation time

<table>
<thead>
<tr>
<th>Variable</th>
<th>Evaluation time</th>
<th>Statistics (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite material</td>
<td>Three days</td>
<td>One week</td>
</tr>
<tr>
<td>Gr_1</td>
<td>3.27^B_b±0.67</td>
<td>6.81^C_b±1.16</td>
</tr>
<tr>
<td>Gr_2</td>
<td>3.75^B_c±0.20</td>
<td>7.76^B_b±0.39</td>
</tr>
<tr>
<td>Gr_3</td>
<td>4.84^A_c±0.59</td>
<td>10.07^A_b±0.57</td>
</tr>
</tbody>
</table>

Statistics (p value):<0.0001*;<0.0001*;0.0019* ns; non-significant (p>0.05) *; significant (p<0.05)

Different superscript large letter in the same column indicating statistically significant difference between groups (p< 0.05) Different subscript small letter in the same row indicating statistically significant difference between time (p< 0.05)

Figure (2): A column chart of color change (ΔE) means values for composite groups as function of evaluation time from baseline

Discussion:

It has been stated that multilayering techniques utilizing resin-based composites of varying opacities and shades can imitate the appearance of teeth (10 and 17). Unfortunately, this restorative procedure necessitates accurate shade assessment and advanced technical skills, which sometimes increase chair time and expense. (9).

Long-term exposure to certain food dyes (coffee in particular) can have a considerable impact on the color stability of modern aesthetic restorative materials, despite the composition of the materials (11).
Therefore, the objective of this study was to evaluate the color stability in single-shade composite in comparison to multi-shade composite. In this study the specimens’ colors were measured using a Reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). A white background was selected and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65, also hue and chroma were recorded. The color changes (ΔE) of the specimens were evaluated using the following formula:

$$\Delta E_{\text{CIELAB}} = \sqrt{\Delta L^*^2 + \Delta a^*^2 + \Delta b^*^2}$$

Where:  
- L* = lightness (0-100),  
- a* = (change the color of the axis red/green) and  
- b* = (color variation axis yellow/blue) (14)

In the present study, evaluating the color stability in single-shade composite in comparison to multi-shade composite; there was found that charisma topaz one shade composite recorded highest color change mean value followed by Venus Diamond one shade composite mean value while the lowest recorded color change mean value was Filtek Supreme 3M composite. For all composite groups, it was found that two weeks evaluation time recorded highest color change mean value followed by one week evaluation time mean value while the lowest recorded color change mean value was after three days evaluation time.

In the current study lowest amount of color change of Filtek-supreme 3M [nanofilled] whereas Charisma Topaz one shade composite [nanohybrid] presented the highest Favor this study results are those Tuncer et al and Nasim et al (18,19) that they reported, more color stability might be expected for nanofilled composites, due to the presence of smooth surfaces with less stains, because of smaller particle sizes.

However, the same inorganic filler concentrations of the composites (Filtek-supreme 3M: 78.5 wt%, Charisma Topaz: 76 wt%) could not be the reason of this difference, the type of the fillers (silica, zirconia and silica/zirconia cluster fillers) and as well as the size of the fillers in Filtek composite might have influenced the color stability Nikolaidis A et al and Tuncer et al (18,20). Another clarification is that triethyleneglycoldimethacrylate (TEGDMA) in Filtek-supreme 3M may increase the surface hardness, elastic modulus and the degree of polymerization, thus contributed to increase resistance against color change Nikolaidis A et al and Gurbuz O et al(20,21). Moreover, In the present study Venus Diamond showed more color change than filtek supreme 3M not in favor by those Nuaimi and Garg(22,23) that they reported that Venus Diamond was lower color change than filtek supreme 3M may be due to type of resin filler and matrix or staining agent type. Also, the results of present study not in favor with Hasani-Tabatabaei et al and Alharbi et al (24) they reported that when exposed to coffee, the nanocomposite Filtek Supreme have more color change followed by Venus Diamond more than other composites. In the current study it was found that Venus diamond showed change in color by time that was in favor with Ardu et al (15) and (25,26,27), they found color of Venus diamond changed, this might be associated with the TCD-DI-HEA monomer specific to Venus Diamond.
CONCLUSION:
Color change increased by time after immersion in coffee presented in all resin-based materials presented. 3M Filtek supreme showed the less color change and charisma topaz was the highest.

References:


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